Current and Future Impact Risks from Small Debris to Operational Satellites

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The collision between Iridium 33 and Cosmos 2251 in 2009 signaled the potential onset of the collision cascade effect, commonly known as the “Kessler Syndrome”, in the low Earth orbit (LEO) region. Recent numerical simulations have shown that the 10 cm and larger debris population in LEO will continue to increase even with a good implementation of the commonly-adopted mitigation measures. This increase is driven by collisions involving large and massive intacts, i.e., rocket bodies and spacecraft. Therefore, active debris removal (ADR) of large and massive intacts with high collision probabilities has been argued as a direct and effective means to remediate the environment in LEO.

The major risk for operational satellites in the environment, however, comes from impacts with debris just above the threshold of the protection shields. In general, these are debris in the millimeter to centimeter size regime. Although impacts by these objects are insufficient to lead to catastrophic breakup of the entire vehicle, the damage is certainly severe enough to cause critical failure of the key instruments or the entire payload. The focus of this paper is to estimate the impact risks from 5 mm and 1 cm debris to active payloads in LEO (1) in the current environment and (2) in the future environment based on different projection scenarios, including ADR. The goal of the study is to quantify the benefits of ADR in reducing debris impact risks to operational satellites.